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DESIGN OF A MANAGEMENT INFORMATION SYSTEM

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ABSTRACT

Several of the important problem areas encountered in designing a management information system for operations and maintenance control of a major weapon system are discussed herein. Three types of design approaches are considered: (1) method and equipment improvement, (2) data augmentation, and (3) decision orientation. The latter approach is illustrated by a weapon system example. Design objectives which are useful in establishing detailed design criteria are discussed. The concepts of this paper are relevant to many non-military systems.

DESIGN OF A MANAGEMENT INFORMATION SYSTEM[1]

The design process is a blend of science and art, whether the final product is a missile or an organization chart. The designer utilizes theory, experience and intuition to arrive at his design decisions. This paper discusses some ideas which are appropriate to the problem of designing a management information system for operations and maintenance control of a major weapon system. The system is characterized by (a) operations in which costly and complex equipments are dominant, (b) operating requirements that are stringent, (c) an environment containing many stochastic elements, and (d) organizations which are in scattered locations, but whose activities must be coordinated. Many non-military systems possess these characteristics, and the concepts of this paper are relevant to these.

The material contained herein deals with two aspects of information system design. The first involves the types of approaches that are common to such system design. The second concerns the formulation of general criteria for guiding the development of a system.

Design Approaches

Quite different approaches are possible for the design of an information system. A common one is equipment and method improvement. Very impressive developments in equipment during the past ten years have resulted in considerable emphasis being placed on better ways to process data. Equipment and method improvement is always welcome because it improves the menu from which the designer may select system elements. In the face of equipment emphasis, however, the early literature of the business data processing field often contained statements to the effect that the fastest and most reliable path to a better system is by way of improvements in data processing techniques.[2] With such an approach an examination of and changes in the existing system are discouraged and most effort is directed toward mechanization of the system in being with perhaps only minor changes. Processing improvements are certainly a desirable goal in situations where the desired end products are well specified, such as some types of record keeping. However, in a system required to produce information for managing or decision making, the end products are often not well specified. In fact, the principal problem lies in determining what the end products should be.

Another approach is <u>data augmentation</u>. This consists of increasing the kinds and amounts of data being collected and stored in the system. In situations where there is either a great paucity of data to begin with, or where there is much uncertainty as to what data is desired by and/or for management, such an approach may be justified. However, an obvious disadvantage of a data augmentation approach is a tendency to collect and process a great deal of useless information. This approach should, perhaps, be confined to relatively short-term, exploratory system revisions.

A third approach can be called <u>decision orientation</u>. In essence, the approach consists of (1) defining the operating and planning decisions that are required to manage an organization, (2) exploring the types of policies available for making each decision, (3) determining the data requirements implied by each decision policy, and (4) developing preferred processing techniques for the desired data set. The decision orientation approach is appropriate for making long term improvements in an information system. An urgent requirement for short-term improvements in a system may require use of the previous two approaches.

A Weapon System Example

In the management of a weapon system, four categories of decisions are:

1. Tactical: Those decisions concerned with the combat commitment of the force.
2. Support: Those decisions concerned with maintaining the combat readiness of the force.
3. Planning: Those decisions concerned with establishing and modifying the force configuration and operating procedures.
4. Equipment Design: Those decisions concerned with modifications of equipment and facilities as a result of field experience.

With a few changes in terminology, these categories apply equally well to a non-military system, in that categories 1 and 2 are concerned with relatively short-term allocation of resources to achieve the system objectives and categories 3 and 4 are concerned with relatively long-term allocations.

There have been many investigations of predictive models to be used in arriving at decisions in the above categories. References 1, 3, 4, 5, 9, and 10 represent only a very few of such. In general, decision policies in the above categories require data inputs on:

(1) Readiness,

(2) Reliability, and

(3) Downtime.

<u>Readiness</u> refers to the degree of capability of the system to perform assigned objectives. This capability is usually measured in terms of the numbers and percentages of weapons which are in various states of alert. Although it is customary to express these quantities in terms of periodic (daily, say) averages, the stringency of assigned objectives in our present-day weapon systems calls for more detail, such as time traces of the above quantities. Another dimension of readiness is the degree of combat effectiveness of the weapon, which for the same reasons should be measured in the same detail as readiness.

<u>Reliability</u> refers to the probable durations of various states of readiness. Maintaining the force in various states of readiness exposes the equipment and facilities to many kinds of stresses. These range in severity from storage in temperature- and humidity-controlled environments to intermittent or continuous operation in uncontrolled environments. There are also the stresses imposed by different maintenance and operating policies. As a consequence of these stresses, equipment malfunctions occur which degrade the readiness of the force and require support actions. Effective management calls for knowledge of malfunction rates related to specific environments, and ideally should be based on time traces of the reliability behavior of equipment related to the environments experienced.

<u>Downtime</u> refers to the kinds and durations of non-ready states. It relates the non-ready times of weapons to different categories of support actions required to produce a desired state of readiness again. Downtime should include at least two phases: <u>active</u> and <u>passive</u>. Active downtime refers to that non-ready time during which resources are available to perform support actions. Passive downtime refers to that non-ready time during

which resource actions are not available. This phase is particularly important for identifying potential shortages in the allocation of support resources to the system. Downtime should be recorded in the same detail as readiness to yield precise, compatible planning information.

Data inputs on the above three aspects of weapon system performance are crucial to effective management. See References 2, 6 and 8 for further discussions of data requirements.

Design Criteria

Design goals for information systems are often either stated in terms so general as to be unmanageable or even meaningless (e.g., "maximum information for minimum cost"), or so specific as to produce undesired emphasis (i.e., minimize the per unit cost of data processing by use of an electronic computer). The problems faced here are quite similar to those faced in selecting performance design objectives for a weapon such as a missile. These criteria provide direction to the study without introducing the rigidity that results from early choice of particular types of equipment or schemes for data processing.

These goals are not independent. The feasibility and cost of various data system techniques should have a pronounced effect on the amount and types of data processed. However, all too often the objective of data system design is stated as optimizing the data processing system, rather than the more desirable objective of optimizing the data decision system (i.e., an optimal management information system).

One objective is <u>weapon-centered recording</u>. This refers to the notion that data recording should be focussed at individual weapon points rather than solely at activities such as supply or maintenance. A weapon point is a basic unit such as an airplane or missile plus all the personnel, test equipment, facilities, fuel, and similar items that are directly related to the basic unit and are necessary for performance of its mission. For a weapon system, the primary consideration is how much useful capability is being obtained per dollar expended and the degree to which various factors affect this capability. The internal efficiency of supporting activities <u>apart from their observable effect on the weapon system</u>, are of secondary importance.

In systems where recording is focussed on individual support activities, data from operations, supply, maintenance, and other activities must be brought together and unscrambled to obtain a picture of each weapon point. This task is difficult, if not hopeless. Support activity records should be kept as a complement to, not as a substitute for, weapon-centered recording.

A second objective is <u>event recording</u>. The system should provide for recording events <u>as they happen</u> rather than recording at periodic intervals. Most of the decision policies being developed for present-day weapon systems require some knowledge of the probability distribution of certain events over time. For this reason, a system which collects input data on a periodic basis is inadequate since it only provides long-run averages. In addition, a system that records events as they happen is not burdened down by many periodic entries revealing nothing new.

A third design criteria is that <u>data handling at the weapon points be kept at a minimum</u>. In general, the collection process is more desirable as the total number of forms or input devices and the complexity of each form or device decreases. The data function at weapon points ideally consists of a simple recording of events as they happen. If at all possible, the individual at the weapon point should not be required to: perform any arithmetic -- even simple additions or subtractions; look up reference data in tables or books; consolidate information from several different sources; and post data from one form to another or keep permanent records of any type. The error rates for these operations when performed at weapon points tend to be prohibitive.

A fourth objective is that no data should enter the system without being checked by some agent other than the originator. A lack of accuracy and completeness is one all too common characteristic of much data collection. No amount of subsequent system accuracy will compensate for initial errors in input data.

A fifth objective is that the system should support the weapon point manager. Data which flows to higher levels of management usually is highly selected and summarized. The local manager needs data in the greatest detail and requires continuous access to data. The local manager will have little interest in maintaining the efficiency of a data collection system which provides no direct benefit to him.

A sixth objective is that data inputs should be consolidated. A characteristic of many industrial and military information systems is that some kinds of data are reported over and over again on different forms which go to different management activities and levels. It is also characteristic that at the same time there is no provision for the reporting of other kinds of data which are crucial to effective management of the weapon system. (See References 6 and 8.) By consolidating overlapping data requirements, data lacks can often be met without appreciably increasing the volume of data flow.

Based on the above principles, a desirable management information system for a major weapon system can be described as follows. At each weapon point every event affecting weapon status is recorded[3] in time-referenced sequence regardless of whether it concerns operations, supply, or maintenance. The record of each event includes time of occurence, the part of weapon point involved, a brief description of the event, the serviceability status (such as type of operation, or type of maintenance, or awaiting some support resource), plus an estimate of combat condition (such as effectiveness at and time needed for combat commitment). The records of events go to a processing system for verification, checking for completeness, referencing, classification, arithmetic operations, posting, summarizing, analysis, and media conversion. As little of this as possible is done at the weapon point. The information requirements for different activities and different levels of management are provided by the processing system from manipulations of the basic event history.

Summary

The decision structure in the management system is a basic determinant of the "preferred" information system. When vague, intuitive decision rules are used, the data requirements are uncertain. As the decision rules become progressively more formalized, the data requirements can be more rationally specified. If an organization is to obtain full benefit from advanced techniques of data processing, then analysis and specification of the decision structure is a practical necessity. An Operations Research type activity can, therefore, make very significant contributions to data processing by the determination and specification of desirable decision policies concurrent to the design or redesign of data processing techniques.

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FOOTNOTES

[1]Read to the thirteenth National Meeting of the Operations Research Society of America at Boston, Mass., May 16, 1958. Also read to the American Ordnance Association, Committee on Proving Ground Instrumentation, at the Pacific Missile Range, Pt. Mugu, California, July 23, 1958.

[2]See Reference 7, for example.

[3]There is no intent to imply a "preferred" technique for the recording (e.g., pencil and paper, or electronic devices). The criteria discussed herein apply to the structure of the information system.